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Artificial Intelligence in a historical perspective

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Abstract. The paper tells the story of the beginnings of Artificial Intelligence (AI) as a scientific venture from a European perspective. The story is embedded into three main steps of history. In view of a sustainable future of our globe it is deemed necessary to vigorously advance the initiated third step. Assuming AI's due role in this process would mean a change in its long-term goal: enhancing rather than simulating human intelligence.

Keywords: History, Artificial Intelligence, Europe, enhancing human intelligence, AI pioneers, Intellectics

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1. Introduction

The quest for an artificial intelligence undoubtedly belongs to the boldest ventures mankind has ever undertaken. Hence the scientific field, from which it originated, viz. Artificial Intelligence (AI), certainly deserves also a historical treatment. Thanks to Nils Nilsson there is now a rather comprehensive historical account of AI available [43].

Without any doubt the main impulses for starting (modern[1]) AI came from the US and major steps were taken there while the rest of the world followed only slowly behind. So Nilsson's account occasionally does not give enough emphasis on aspects of (modern) AI's history from the point of view of other regions in the world.

In order to compensate for this bias the present paper tells the story of AI's beginnings from a European perspective taking Nilsson's book and its contents for granted. As any such story, also our's consists of prominent persons involved, of leading ideas, significant events and memorable moments. It roughly spans the period between the forties and the eighties of the last century. Due to the nature of this paper it does not contain a comprehensive account of those years by any means, and is itself biased by the limitation of the author's own recollections, experiences and the documents accessible to him.

[1]As Nilsson shows AI's history extends back many centuries while we restrict our discussion here on the period after the invention of the modern universal computer.

Recalling how AI started brings also back to mind the vision pushing those early developments which aimed at a full understanding and computational realization of intelligence. To some extent that vision got lost several generations of AI researchers further down. Typically, an AI researcher today is a specialist in some AI method, subfield or application without much pondering on more general aspects of this fascinating field.

While in the early days of AI that vision was considered a scientific opportunity, today it appears more like a necessity for preventing a disadvantageous course of our world. In order to stress this urgency I embedded the paper's account of AI's history into a view of the global history under which AI is an essential part of a pending third major step in evolution. If we agree on this view, a great responsibility rests with us in the challenge to overcome the huge global problems the world is facing because of mankind's occasionally irrational behavior. Indeed, "humans ... need help to make more accurate judgments and better decisions" [35] and AI has the potential to provide such help. With such a role for AI in mind its long-term goal changes from simulating to enhancing human intelligence (not unlike medicine which helps to enhance humans' health).

2. The pre-Zusean situation

Once upon a time there were scientists who had never seen a computer, never thought of solving a problem algorithmically and never asked Google for some

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information. At the time when I was awarded my PhD this was still true for most scientists including myself (and any other people for that matter). In other words, not that long ago this was the normal situation, a fact we tend to forget in these days of ever accelerating technological progress. Therefore I would like to draw the attention to the frame of prevalent thinking in those days.

Let me label that thinking as *pre-Zusean*.[2] As there are still many people in this world without any knowledge of concepts underlying information technology (IT) and AI, pre-Zusean thinking still abounds in our times, even among scientists of many disciplines. On the other hand, great minds – like Gottfried Wilhelm Leibniz (1646–1716) or Charles Babbage (1791–1871) – envisioned Zusean mechanisms, realized only in our days, already centuries before Zuse (of whom more in Section 4.1). So Zusean thinking did not enter this world at a particular point in time, but rather over a long and ongoing period of time.

The physicists were the heroes among the pre-Zusean scientists. Their theories successfully covered a great deal of the phenomena in the inanimate world. Meanwhile it has become clear, by events like Hiroshima, Chernobyl, Fukushima or the climate change, that, in any comprehensive perspective, Physics can only be a part of the story.

Encouraged by their erstwhile success physicists entered and revolutionized even biology. The physicists Max Delbrück (1906–1981) and Erwin Schrödinger (1887–1961) directly influenced with their biological work [54,66] James Watson (*1928) who along with Francis Crick (1916–2004) in 1953 discovered the structure of the DNA as a macro-molecule in form of a double helix. Outstanding as their discoveries were though, none of these scientists (let alone conventional biologists) had the slightest Zusean understanding of the information processes involved, to which we will come back in the next section.

Pre-Zusean psychology, especially in the US, centered on measuring specific behavior in response to specific stimuli, known as behaviorism. Burrhus Frederic Skinner (1904–1990) is the most famous representative of this direction. "What went on between the ears after the stimulus was received and before the response was given" [58] was deemed not of any interest for most psychologists. There are a few exceptions to this general tendency like Otto Selz[3] (1881–1943). But again no psychologist had the slightest Zusean understanding of the information processes involved.

Certainly until the middle of the last century this is all the more true for all social sciences and humanities. *A fortiori* it is true for the general public, for individuals in their private lives, for decision makers in organizations, businesses or politics. All of them are prone to the daily mistakes and misunderstandings in communication, to the false pretense, defamation, falsehood and deceit among people, to the systematic biases in human judgments and decisions like those revealed by the work of Daniel Kahneman [35] and his colleagues.

3. The pending third step in macro-history

In the preceding section we distinguished pre-Zusean from Zusean thinking by alluding to biology and psychology, two disciplines which underwent fundamental changes through this change in the frame of thinking. In the present section I try to make this distinction still clearer by drawing a very rough picture of the global history.

Science assumes that the physical laws as known today have governed the development of the cosmos since the "big bang", a singularity which occurred about 14 billion years ago and is inferred from available cosmic physical data on the basis of those laws, principles and theories.

From the vantage point of those physical laws something strange happened in the period of 3–4 billion years ago: forms of life appeared on earth. This first step in our macro-history is characterized by the evolutionary discovery of *information coding and inheriting*.[4] This discovery enabled organisms to escape up to a certain extent from the strict rule of physical laws and to decrease or maintain their entropy. By way of

[2] Konrad Zuse (1910–1995) built the first general purpose computer, designed the first (modern) programming language (Plankalkül) in the last century – i.e. after Ada Lovelace (1815–1852) – and wrote in it the first chess program. The term is invented in honor of this genius.

[3] For more details and further names see [13, Section 2]. Examples of work of these early pioneers are (also) discussed in [3]. An early example of Selz's work is his Habilitation thesis concerned with the actualization of knowledge and published as [55].

[4] The characteristic feature of DNA encoding and inheritance consists in the novel use of a language for coding which to my knowledge is unknown in the inanimate physical world. Of course, if for instance a physical particle with a certain momentum hits another one, a sort of momentum inheritance takes place. So, taking the momentum as coded information, information inheritance takes place even in such a purely physical process which obviously occurred long before life emerged, but no language is crucially involved as in DNA encoding.

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a code realized as a chemical molecule like the DNA it became possible to set goals for the organism within the environment, to represent its compositional and organizational structure, its functioning as well as its development.

In terms of Zusean thinking nature had discovered in this first step the idea of the analogue of a computer program which controls the organism's growth and survival in a certain niche of environment. Through metabolism energy is supplied from the surroundings thus coping with the second law of thermodynamics. By replication this sort of program can even be passed on to next generations and by mutations it can be optimized and adapted to (changes of) the environment. This deeper understanding of the inherent nature of *life as an information processing organism* in lack of the insights gained only during the last 70 years could not be achieved by the scientists of the pre-Zusean variety such as Schrödinger.[5]

For billions of years organisms had no access to the information coded, for instance, in their genes and in their central nervous system (CNS). This enabled life to evolve into a wonderfully balanced nature. But then a second fundamental step took place in the evolutionary history: creatures such as humans obtained access to some of the information processed within their bodies. That is, we are able to be aware of some of the input into our senses. We can store and memorize it and in this way build a conscious model of the environment and accumulate knowledge about it. With such knowledge we can explain observed phenomena and even make predictions. Any such knowledge can be passed on to later generations. In essence the evolution had discovered (part of) the meta-knowledge level in information processing: we know about (some of) the information processed in ourselves.

Endowed with these additionally evolved talents humans became the rulers of this world. We can extinct any species at will and have done so already with appallingly many of them [28];[6] we can, and do, destroy entire ecosystems, in fact we have even the means to destroy the entire Earth.[7] Last but not least humans have used these talents to keep doing harm or even kill other humans in the millions. On the other hand due to human ingenuity we now have a deep understanding of nature and its functioning. For many people life has become rather comfortable, secure and fulfilling. And science has opened attractive prospects of a prosperous future for all creatures on earth. How could we make these beneficial prospects come true and avoid those threatening tendencies?

It is my central thesis that nothing less than a third step in the evolutionary history is required, in fact crucial for the prosperity of humankind, and that Artificial Intelligence (AI) is a part of it. Despite their extra talents humans in the first place are animals who strive for survival on an individual basis. We are rather bad in thinking in an unselfish, global mode, any of us, the man on the street as well as the president of a powerful nation. People hold all kinds of crazy beliefs (among many reasonable ones) and base their judgments thereon. In their partially succeeding communications they misunderstand each other continuously or distort the true facts on purpose or unwillingly. They are prone to numerous effects which contradict rational judgment.[8]

It is exactly these weaknesses that cause the threatening tendencies described. There are therefore only two alternative ways to overcome these weaknesses and their detrimental consequences: either change human nature or compensate the weaknesses in an organizational and technical way based on Zusean thinking. Since changing human nature has so far proved impossible (except for relatively minor educational improvements), only the second alternative seems available to us.

This *Zusean alternative* means that we attempt to build an artificially intelligent agent which on the one hand matches human intelligence and on the other does not suffer from human weaknesses and failures. In other words the third step would result – were it successfully completed – in a situation where we not only

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[5] In order to avoid any unintended offenses I stress that in no way this statement is meant to undermine the great value of the work by eminent scientists like Schrödinger. It is the change of the mind frame that took place which I try to illustrate with Schrödinger's work mentioned before in comparison with later biologists of the Zusean variety.

[6] Last access May 2012, same for all subsequently noted webpages unless stated otherwise.

[7] During the so-called cold war this was a realistic threat due to the atomic weapons arsenal which fortunately has become less realistic at present.

[8] Kahneman [35], presents an entire book full of the results of a wide range of carefully carried out psychological studies which demonstrate our biases, i.e. systematic human errors which are "traced ... to the design of the machinery of cognition ..." (p. 8). Even trained scientists in their own area of expertise are prone to these errors, let alone decision makers, politicians, voters, or normal people.

Unfortunately, Kahneman's own recommended lessons from these insights like "... more precise gossip at the watercooler ..." (pp. 4, 418) seem too pallid and inappropriate for what is at stake.

Daniel Kahneman, Professor of Psychology, received the 2002 Nobel Prize in Economic Sciences.

know about *some* information processed in ourselves but also know about the mechanisms underlying these processes. In other words, after successfully performing this step we would be in full command over these mechanisms and thus over the *entire* meta-knowledge level, the goal of AI from its very beginning.[9] So the pending third step in evolution involves a conquest of the full meta-knowledge level.

In summary, with the term "Zusean" we try to circumscribe the meta-level methodology which came about with the invention of the modern computer. The computer provided us with a model of how thinking might take place in our heads. Many aspects in psychology, sociology, politics, in all of science, were modeled in a computational way for the first time. We learned how to mimic natural communications, sensing and its processing, represent knowledge, model reasoning steps, form and execute decisions, make explicit the differing beliefs in political disagreements, form scientific theories and hypotheses, and so forth. In contrast to the pre-Zusean period all this was achieved in a truly scientific approach.

4. The dawn of a new age

As already pointed out in Section 2 Zusean thinking did not come about at a particular instant in time. Rather the third step in our macro-history from the previous section is underway already for some time and will take decades, or even centuries to be completed to some degree. Many so far have contributed in getting it started, mostly only with a hunch as to where it eventually could lead.

In the present section I will describe some of the developments in the early days of AI with a strong emphasis on the European scene for the reasons given in the Introduction. Thereby I try to avoid too much overlap with the contents of two comparable articles published earlier by this author [13,15], so that the three articles can to some extent be regarded as complementary.

4.1. Inceptions of AI thinking

New ideas come into the world through individual thinkers. As to Artificial Intelligence there are a number of prominent figures who provided first clues and dreams. Many of them and their ideas are described in the first chapter of Nilsson's book [43] already mentioned in the Introduction so that there is no need to recall them here.

While Nilsson acknowledges Konrad Zuse's achievement of building the first (general, programmable, modern) computer, completed and operative in 1941,[10] he fails to mention his contributions to AI. Due to the misery of the period during the 2nd World War Zuse in early 1945 had to retreat to a little village (Hinterstein near Hindelang, later moving to Hopferau) in the Allgäu mountains in Germany. In lack of a laboratory he was sort of forced to do some theoretical work which resulted in his Plankalkül, the worldwide first universal programming language. With full justification it can be called the first AI programming language, designed not least with the idea in mind to represent chess playing in it. Its development was carried out and used for coding the first chess program in history, both in 1945/1946 [71,73].[11] In lack of an implementation of the Plankalkül in Zuse's lifetime, the chess program was never run on a real machine.[12]

Zuse's main interest however remained in building computers.[13] Also, he had to earn a living for his growing family. The German academic world to a large extent kept ignoring him, let alone offering him a suitable position, for decades. For all these reasons he had no opportunity to continue pursuing these initial, though substantial steps into AI.

Andrew Donald Booth (1918–2009), director of the computing center of the Birkbeck College at the University of London, as early as in 1946 suggested to use computers for language translation and discussed the idea with Warren Weaver (1894–1978), vice-president of the Rockefeller Foundation. On the basis of these interactions in 1949 a memorandum "Translation" was written by Weaver and sent to the groups involved in research on machine translation. This initiative led to the first Conference on Machine Translation at MIT in June 1952 where most researchers in that field, including Booth, met [38]. It was organized by MIT's Yehoshua Bar-Hillel (born Oscar Westreich, 1915–1975), the first academic to work full-time in the

[9] See the citation at the beginning of Section 4.2.

[10] While the history of the origins and beginnings of the modern computer is complex (and not a topic here), Zuse's pioneering contribution is undisputed, although often understated. E.g. see [51].

[11] See also [72], pp. 112–118. The Plankalkül was implemented only in 1998 and again in 2000.

[12] For this reason the credits for writing the first chess program are now with Claude Shannon [57].

[13] Zuse's life is portrayed in [23].

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field of Machine Translation (MT). For the years to come, MT despite its close relationship stayed apart from the emerging discipline of AI.

The European intellectual founder of AI without any doubt was Alan Mathison Turing (1912–1954). Turing was strongly influenced by the work of David Hilbert (1862–1943) and Kurt Gödel (1906–1978) which led to his famous 1936 paper introducing what is now called a Turing machine, the universal Turing machine, the concept of a computable number, etc. and presenting a proof of the undecidability of first-order logic [68,69]. The two years 1936–1938 he spent in Princeton, NJ, studying and obtaining a doctorate under Alonzo Church (1903–1995), another hero in mathematical logic, a discipline which is one of the founding corner-stones of AI (and of CS for that matter) [50]. Among a lot of other work on a variety of topics (including statistics, cryptography, the first detailed design of a program-stored computer, program verification, morphogenesis[14]),[15] Turing in 1950 published his famous Turing Test paper [67] which has remained sort of a manifest for AI since then.[16] It is worth noting that Turing met Zuse in a colloquium which took place in Göttingen in 1947 [20,26].

Chapter 1 in Nilsson's book [43] also mentions Norbert Wiener (1894–1964), but like with Zuse he somewhat understates Wiener's influence in the birth of AI thinking. Wiener also enjoyed a strong background in mathematical logic. In fact his PhD from Harvard, received at the notable age of 17, made a remarkable contribution to this discipline and as a postdoc he studied under Hilbert[17] in Göttingen [29]. Wiener, in the meantime a professor at MIT, became famous through his book on cybernetics published in 1948, a term he and his collaborators introduced for the discipline studying natural and technical phenomena involving feedback. His fame helped MIT to recruit a rather competent research team working on topics which today are associated with AI and cognitive science. It is natural that this group to some extent fertilized the grounds for the AI department at MIT, to be founded a few years later.

Wiener's work found followers in other parts of the world, e.g. in Germany.[18] The physicist Karl Steinbuch (1917–2005) was among them. In the years 1948–1958 he led the development of the first European fully transistorized Computer (ER 56) [30]. In 1958 he became a professor at the Technische Hochschule Karlsruhe. He developed and built the worldwide first practical adaptive neural net,[19] the "Lernmatrix" for which he received patents already in the mid-fifties [60].[20] The Lernmatrix did not suffer from the deficiencies of Rosenblatt's perceptron.[21] Like Zuse, Karl Steinbuch envisioned the modelling of intelligent functions such as learning, pattern and "Gestalt" recognition by digital computers. But again his work had no impact on AI's development and until this day is not recognized within the AI community (e.g. it is not mentioned in Nilsson's book). In 1957 he also invented "Informatik", the German term for Computer Science [63], by which he understood information processing *including* the kind familiar in AI. Even a year before Gordon Moore's first statement of what today is called Moore's Law [42] Steinbuch published similar logarithmic plots of the evolution of processor speed and memory capacity [61]. What Wiener was for MIT, Steinbuch was for the Karlsruhe Institute of Technology (as it is named today) which later has become one of the institutions with a strong AI section in Germany.

As an example for some AI stuff under the cybernetics label,[22] the anthology "Kybernetische Maschinen" published in 1964 [24] covers a wide spectrum of topics which could as well have been collected in an AI volume of that time had AI existed then in Germany as a discipline. They include language translation, language generation, learning automata, computer aided instruction, law, medicine, and even topics like "elektronisches Gehirn" (electronic brain) or consciousness.[23] The cybernetics paradigm was too restricted to

[14] See Aaron Sloman's paper in this issue.

[15] See the articles in [67].

[16] See Stephen Muggleton's paper in this issue.

[17] Hilbert, already mentioned in connection with Turing, apparently had an indirect influence to the birth of AI. He also extended his influence to the work of the present author who was supervised for his PhD by Kurt Schütte (1909–1998), Hilbert's last PhD student.

[18] As noted in the Introduction the presented material is not comprehensive by any means. But we mention as further examples the following two British researchers: Andrew Gordon Speedie Pask (1928–1996) [59] and Albert M. Uttley [70].

[19] The general concept itself was first introduced in [41].

[20] The patent [62] refers to several (out of altogether 80) earlier patents of Karl Steinbuch which he received for his work at Standard Elektrik Lorenz (SEL) between 1948 and 1958 which already contain the essential ideas of the Lernmatrix and which precede Rosenblatt's work. For a historical comparison see [64]. See also [31].

[21] See e.g. [43], Section 4.2.1, as well as [52].

[22] Non-numeric applications were also presented under the label of automata theory within a spring school of physics series, a telling curiosity [22].

[23] See also [27].

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serve as a common roof for such a wide range of interests.[24] Therefore, those who really understood the great potential of the computational paradigm underlying the Zusean alternative, like Steinbuch, remained isolated.

4.2. The post-Dartmouth period

Under the date of 31 August 1955 John McCarthy (1927–2011), Marvin L. Minsky (*1927), Nathaniel Rochester (1919–2001), and Claude E. Shannon (1916–2001) completed a proposal for a 20 man-months study of artificial intelligence: "*The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it*". This truly Zusean proposal received approval and secured funding of $7,000 from the Rockefeller Foundation so that a summer workshop took place in 1956[25] with 10 attendees at Dartmouth College, McCarthy's home institution then. Among these attendees were the leading figures who would dominate the field in the forthcoming decades from leading institutions such as CMU, MIT, Stanford and IBM in the US. They jointly and perseveringly pursued the vision which Turing, Zuse, Steinbuch, and others had shared but for various circumstantial reasons were not able to get off ground.

AI derived its name from this proposal. Since AI in contrast to the proposal's vision narrowed its domain considerably (into a sub-discipline of CS or Informatics) in the subsequent decades, resulting in the unfortunate split between AI and Cognitive Science (CogSci), the present author keeps proposing the term *Intellectics* [6][26] as a name for a united and truly Zusean discipline comprising both AI and CogSci (as well as respective parts of Neuroscience, Psychology, Philosophy, etc.) under their original vision.

In November 1958, a symposium on the "Mechanisation of Thought Processes" was held at the National Physical Laboratory in Teddington, Middlesex, England. According to the preface of its proceedings this symposium was held "to bring together scientists studying artificial thinking, character and pattern recognition, learning, mechanical language translation, biology, automatic programming, industrial planning and clerical mechanization." Leading AI researchers, also from the US, attended.[27] So the UK got acquainted with the new ideas at a quite early stage.

Continental Europe got notice of these developments in the US and UK to a limited extent through the First International Conference on Information Processing (IFIP) in Paris a year later in 1959. Here Dag Prawitz from Stockholm presented the first theorem proving system for first-order logic.[28] He represents one remarkable instance of the sporadic and totally scattered work done in continental European AI in those years.

The first academic institution in Europe which established an AI department was the University of Edinburgh. In 1965 Donald Michie (1923–2007) with a PhD in mammalian genetics from Oxford University became the director of its Department of Machine Intelligence and Perception (before 1966 named the "Experimental Programming Unit"). This department predated the university's computer science unit. During the war Michie had worked at Bletchley Park in a group with Alan Turing deciphering German secret code, whereby the two might occasionally have discussed "the possibility of artificial intelligence".[29]

Independently, Bernard Meltzer (1916–2008) set up a research unit at the same university to pursue his interests in mathematical logic and a growing appreciation of the unexploited possibilities of the use of digital computers. Called the Metamathematics Unit, it quickly established an international reputation as a centre for research in artificial intelligence, extending the scope of its work on automatic proofs of mathematical theorems to other activities such as modeling induction and commonsense reasoning. Many of the researchers who emerged from that unit became major figures in AI.[30]

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[24] In the eastern bloc, cybernetics nevertheless continued to play a leading role similar to AI in the west until the eighties, as the following book demonstrates [39].

[25] Around the same time two other important meetings took place in the US: A Symposium on Information Theory, September 1956 at MIT, organized by the Institute of Radio Engineers, with the proceedings published as *IRE Transactions on Information Theory, IT-2*, no. 3, 1956, for some CogSci researchers the beginning of CogSci. A five weeks Summer Institute for Symbolic Logic at Cornell University in 1957, bringing together logicians and computer scientists, http://math.stanford.edu/∼feferman/papers/cornell.pdf.

[26] See also [10].

[27] For instance, the proceedings contain McCarthy's famous Advice Taker Paper [40].

[28] Bibel [15] gives a detailed account of the development of this system.

[29] Robinson [50], p. 201. See also Stephen Muggleton's paper in this issue.

[30] For instance, Bob Kowalski, Bob Boyer, J Moore among others received their PhD from this institution and Alan Bundy moved there after receiving his PhD.

Meltzer got his PhD in Mathematical Physics from the University of London. In 1955 he was appointed to a lectureship (later readership) in the University of Edinburgh's Department of Electrical Engineering. By invitation of NASA he spent time working at Stanford University during 1962 where he might have come into contact with – or at least heard of – McCarthy who became Professor there in the same year. These and other influences led him to change subjects and start a leading career in AI. Along with Michie he organized a series of workshops on Machine Intelligence[31] and edited corresponding books with the same title.[32] In 1969 he signed an agreement with the publishing company Elsevier[33] to serve as editor of the now prominent journal of Artificial Intelligence, a role he most successfully fulfilled until his retirement in 1978. 1972–1976 he also served as chairman of the Society for the Study of Artificial Intelligence and the Simulation of Behaviour (AISB or SSAISB), the first professional body for AI in Europe – and in the world for that matter – established as a study group in 1964 and transformed to a learned society by him in 1973.[34] Under his guidance the first AI course, AI2,[35] was launched in 1974/75. An introductory course, AI1, was launched in 1978/79 and by 1982, the department was able to offer its first joint degree, Artificial Intelligence and Linguistics. Meltzer actively spent the time of his retirement in Italy.

4.3. First steps in continental Europe

In the fifties of the last century in all parts of Europe (England, Germany, Sweden, Italy,[36] etc.) the design and building of computers was undertaken. As we have seen in Section 4.1 this inspired individuals to think of non-numerical applications of these new devices, a trend which intensified in the sixties all over the world. However, organized research in AI-related topics within universities and national laboratories took place only in the US and the UK where it received considerable institutional support. Some important ones of those institutions were already mentioned above. A further example worth to be noted is the Argonne National Laboratory at Chicago, IL, where J. Alan Robinson (*1930) in 1962 (re-) discovered resolution and unification.[37]

None of the continental European institutions followed suit.[38] The reasons for this ignorance in continental Europe, which in effect lasted until the eighties, of an emerging field with such a remarkable potential as AI, could only be revealed by a thorough historical and sociological investigation which is beyond the possibilities of the current author. The lessons from history are that radically new ideas with a great potential were seldom welcome right away which provides some explanation. But why was there such a wide gulf between the Anglo-Saxon and the continental European world? So we can simply state the fact that no leading scientist in continental Europe sided with AI and its ideas. On the contrary those involved in establishing CS or Informatics in the sixties were quite hostile toward AI. They were encouraged in their attitude by – among other judgments and events – the findings of the notorious Lighthill report [37] in the early seventies. One of the UK's main funding bodies for university research, the Science Research Council, had asked Professor James Lighthill, a famous hydrodynamicist at Cambridge University, to undertake an evaluative study of artificial intelligence research. His conclusions were crushing for AI and had effects not only in the UK, but in all of Europe.

Only young researchers with some independence in the choice of their research topics like Gerd Veenker (1936–1996),[39] studying the IFIP proceedings or similar sources, started to do work in AI, even in the communist Eastern Europe.[40] Several of them found op-

[31] The first workshop in this series took place in September 1965.

[32] The first volume in this series appeared in 1967.

[33] Elsevier and North-Holland merged per 1 January, 1970. Einar Fredriksson, as publishing editor at North-Holland since 1969, stood at the cradle of the journal.

[34] For further details concerning the foundation as well as the history of AISB see Eduardo Alonso, The AISB: 1964 and all that (up to 1980). Talk given at the University of Edinburgh (September 2012).

[35] The numbering reflects the year at which the course was offered; this was offered to 2nd year students (Alan Bundy, personal communication).

[36] Historical information about the machines built in Pisa can be found at http://cctld.it/storia/doc/lettera_fermi.html (accessed 17.09.2012).

[37] Bibel [15] gives a detailed account of this discovery.

[38] There were, across continental Europe, special institutes pursuing topics of relevance for AI, however. An example is the Divisione Linguistica (linguistic division) of CNUCE (Centro Nazionale Universitario di Calcolo Elettronico) at the University of Pisa which in 1978 was baptized Istituto di Linguistica Computazionale (ILC); the division was founded in 1969 and headed by Antonio Zampolli. Prior to this position Zampolli was an assistant to Roberto Busa of the Centro per l'Automazione dell'Analisi Linguistica (CAAL) di Gallarate in the huge project Index Thomisticus sponsored by IBM.

[39] Bibel [15] gives a detailed account of Veenker's contributions.

[40] Bibel [13] presents some information about AI research in the DDR (German Democratic Republique).

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portunities to spend some time in US or UK.[41] Among them was the present author who through the intermediary of Julius Richard Büchi (1924–1984) of Purdue University became assistant professor at Wayne State University in Detroit where he stayed for the academic year 1970–1971. During this time he learned about quite a different kind of scientific and academic world than that in the Europe of those times. For instance he attended the 3rd ACM Symposium on Theory of Computing (STOC) which took place May 3–5, 1971, at Stouffer's Somerset Inn, Shaker Heights, Ohio and featured Stephen Arthur Cook's (*1939) historic presentation of the P-NP problem in his paper on "The Complexity of Theorem-Proving Procedures". He met McCarthy (among other celebrities) for the first time at the fifth meeting of the IFIP working group 2.2 (on Formal Language Description Languages) in Boston in 1970, wrote his first emails, and last but not least wrote and tested his first theorem proving program coded in SNOBOL.

Similarly, Erik Sandewall (*1945), now Linköping University in Sweden, spent one year (1966–1967) at McCarthy's Artificial Intelligence Laboratory of the Stanford University as graduate student, some further time in 1970 as a visiting researcher at the same institution, and one year (1974–1975) as visiting associate professor at the MIT Artificial Intelligence Laboratory. Alain Colmerauer (*1941), after completing his PhD at the University of Grenoble, spent the years 1967–1970 as assistant professor at the University of Montreal; thereafter he moved to the University of Aix-Marseille at Luminy in 1970. Bernd Neumann (*1943), after his Diploma from Darmstadt University of Technology studied four years at MIT where he got an MS in 1968 and his PhD in 1971; then he moved to the Hamburg University joining the vision group there. Marco Somalvico (1941–2002), after obtaining the degree "Dottore Ingegnere" from the Politecnico di Milano in 1965, spent three years of research at Stanford University before, in 1971, he founded an AI group at his Italian alma mater. Gérard Huet (*1947), now at INRIA Paris, in the years 1969–1972 studied Computer Science at Case Western Reserve University, Cleveland, Ohio where in 1970 he obtained an MSc, and in 1972 his PhD Vadim Stefanuk from Moscow around 1970 spent a year at MIT and later translated more than 20 AI books into Russian. Luigia Carlucci Aiello (*1946) received a NATO Grant to spend the two years 1973–1974 as a visiting scholar at McCarthy's Artificial Intelligence Laboratory of the Stanford University, and visited there again 1979–1980 through the Italian CNR and an ARPA grant. Robert (Bob) Anthony Kowalski (*1941), now emeritus from Imperial College, was born in the US where he got his MSc in 1966 from Stanford University and then moved to Europe.

These and many other young researchers spread the news of AI in all of Europe. They tried and succeeded to catch up with the US as to the level of quality of their research. Their papers began to appear in international journals and conferences in the seventies. And they started building a net of personal relationships with colleagues across Europe (and beyond) for exchanging ideas and experiences. The first initiatives to institutionalize national AI groups took place. The first – except for AISB in Great Britain, as mentioned above – was started in Germany in 1975 by Gerd Veenker.[42]

5. Establishing European AI

The first International Joint Conference on Artificial Intelligence (IJCAI) held in Washington DC in May 1969 was co-sponsored by AISB [2] and attended also by European AI researchers. Some of these gathered in a special meeting during the conference. They agreed to take steps towards better contacts among European researchers in AI including starting a European Newsletter in coordination with the existing AISB Newsletter. A letter dated 25 June 1969 from Erik Sandewall who attended the meeting, summarizing the results of the meeting and making further suggestions, was published in the subsequent July 1969 issue[43] of the AISB Newsletter which at the same time changed its name to become "European AISB Newsletter" which it carried until November 1972.[44]

[41] Among those quite a number never returned to their home countries amounting to a painful brain drain.

[42] The workshop "Künstliche Intelligenz", initiated by Veenker and taking place 18 February 1975 in Bonn, featured 43 attendees. In contrast, the annual conference of the Gesellschaft für Informatik (GI) in the same year 1975 among its 53 talks had not even a single one on an AI topic. This discrepancy demonstrates the urgent need of the AI community in Germany (and similarly in the rest of continental Europe) for a platform to communicate its research results. Bibel [13] gives a complete account of these developments in Germany, especially in Sections 3 and 4.

[43] See [2], pp. 1–3; special thanks are due to Eduardo Alonso who provided me with a copy.

[44] Further names used in the subsequent years were "Bulletin", "European Newsletter", "Quarterly".

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Unfortunately, this initiative remained mostly unnoticed among AI researchers in continental Europe.[45]

With the growth of AI research across Europe the need for exchanging the results in workshops and conferences on a national and international level rose considerably during the seventies. Out of more than a dozen of such events in the mid-seventies all over Europe[46] let us mention the one week international workshop on Automated Theorem Proving (ATP) which was organized by Michael M. Richter (*1938) together with Woody Bledsoe (1921–1995) from the University of Texas at Austin in January 1976 at the mathematical research institute, Oberwolfach (in the Schwarzwald), an event which today is counted as CADE-2[47] in this series of international conferences on automated deduction. It attracted 35 participants from 6 countries (12 from the US) including most internationally leading researchers in Automated Deduction (AD).[48] Further, in May 1976 Bob Kowalski organized the first Logic Programming Meeting[49] in London with substantial international participation. Also, in the third German AI workshop in 1977, chaired and organized by the present author, the 77 participants came already from 8 different countries.

These experiences called for a closer collaboration in AI on a European level beginning in early 1976. The evolving web of personal communications among European AI researchers provided a solid basis for the institutionalization of the collaboration. After several informal discussions and correspondences[50] Hans-Hellmut Nagel, from one of the Informatics departments in Germany with a strong AI section and Chair of the committee representing AI in Germany[51] in a letter dated 25.10.1976 to Michael Brady, the Chair of AISB, proposed to organize a joint conference. In April 1977 Nagel participated in a meeting of AISB in Bristol where full agreement on the details was reached. The resultant joint AISB/GI Conference took place in Hamburg, 18–20.7.1978, Nagel acting as conference chair and Derek Sleeman as Program Chair. It featured more than 80 submitted papers and 180 participants from 15 countries and thus was the first major international AI conference event in continental Western Europe.

The leading international conferences for AI since 1969 have been those of the biennial IJCAI series already mentioned above. Although IJCAI-71 took place in London and IJCAI-75 in Tbilisi in the USSR, the programs of these conferences until the early eighties were heavily dominated by work from the US.[52] In order to draw the attention of the US researchers to the substantial work done in the meantime in continental Europe and to the emerging institutionalization of the European AI community, Jacques Pitrat and Erik Sandewall as co-chairs organized an Invited Panel at IJCAI-77, a conference which took place at MIT and featured 800 participants. Further panelists were Wolfgang Bibel, Gérard Huet, Hans-Hellmut Nagel and Marco Somalvico. These six panelists gave an overview of the AI people and their work in France, Germany, Italy and Sweden which is contained in the

[45] It is perhaps telling that the present author learned of this initiative only in July 2012 for the first time although then he worked since 1969 at the TU München, one of the leading institutions for CS in Germany.

[46] Bibel [13] describes many of these events in Section 4.2.

[47] The Symposium on Automatic Demonstration which took place 1968 at IRIA in Paris-Rocquencourt is counted as CADE-0 and the workshop at Argonne in 1974 as CADE-1 (http://www.cadeinc.org/Conferences.html). The proceedings of the 1968 symposium are published in [48]. In Bibel [15] the Oberwolfach workshop erroneously was labeled CADE-3 rather than CADE-2 (because of counting from 1 rather than from 0).

[48] The "proceedings" consisting of a list of handwritten extended abstracts can be found at http://oda.mfo.de/view/viewer.jsf under "Tagung 05", image 109ff.

[49] Robert Kowalski had taken a leading role for logic programming by his remarkable talk at IFIP-74 in Stockholm. See [36].

[50] The archive of the Darmstadt University of Technology keeps files of Wolfgang Bibel which among others contains a selection of his correspondences. This includes a letter dated 18.03.1976 by Gérard Huet in response to an earlier one by Bibel, in which the two already discuss the chances for the foundation of a European AI organization, as well as a letter exchange with Hans-Hellmut Nagel dated 06.05.1976 in which even an IJCAI in Germany is considered for 1979.

Similarly, the files of Hans-Hellmut Nagel contain important documents from this preparatory phase: (i) A note dated 29.04.76 of a discussion with Wolfgang Bibel concerning the idea of a joint conference with AISB; (ii) a letter dated 07.10.1976 to Jörg Siekmann, who at that time studied at Essex, asking for exploring the chances for this idea with Mike Brady at the same department; (iii) Siekmann's encouraging response letter dated 22.10.1976.

[51] The committee was called Fachausschuß 6 of the Gesellschaft für Informatik (GI). See [13] for details.

[52] Vadim Stefanuk from the Russian Academy of Science informed me (email of 22 September 2012) that apart from the proceedings of IJCAI-75 published by IJCAI Inc. there were proceedings of IJCAI-75 published in Russia. These contained papers of Russian authors not included in the western ones. According to Stefanuk at that time Michail Tsetlin, Mickle Bongard, Victor Varshavsky, Dmitrii Pospelov, Vadim Stefanuk, and others were working in the USSR in the field of AI. Unfortunately, the present author is not in a position to provide a fair account of the research in AI in the USSR and in other countries within the "eastern bloc" of those days.

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proceedings.[53] Particular strengths of European AI in those years were, for instance, in the areas of theorem proving, logic programming, natural language processing, and vision.

Due to the remarkable success of the AISB/GI conference[54] following the previous two AISB conferences in Brighton (1974) and Edinburgh (1976),[55] AISB decided to hold its subsequent meeting again on the continent as AISB-80 in Amsterdam with Bob Wielinga as General Chair.[56] The AISB people argued that AISB was meant as an international society from its very beginning and could therefore justifiably play the leading role also for Europe.[57] This view was not shared by researchers from continental Europe who with good arguments considered AISB as a British organization. In October 1979 Wolfgang Bibel had written a letter[58] to about 30 major AI figures within Europe arguing for the foundation of a European AI society which under these circumstances understandably met with fierce opposition from AISB,[59] but with overwhelming approval from the rest of Europe. The AISB-80 conference was therefore filled with extensive discussions on this issue. An Extra-Ordinary AISB Committee Meeting on 2 July 1980 finally agreed on establishing a coordinating European AI body separate from AISB.[60] Dennis de Champeaux was assigned to coordinate the process of working out the statutes for ECCAI, the European Coordination Committee for Artificial Intelligence, as an umbrella organisation whose members are national AI societies such as AISB, GI (FA6, now GI/KI), AFCET (now AFIA), NVKI (now BNVKI/AIABN), etc. It was also decided to hold the first ECCAI-sponsored European Conference for Artificial Intelligence (ECAI) 12–14.7.1982 at Orsay with Yves Kodratoff as General Chair, Peter Raulefs Program Chair, Derek Sleeman Financial Co-ordinator. In

[53] Artificial Intelligence in Western Europe, *Proc. 5th International Joint Conference on Artificial Intelligence*, 1977, pp. 955–969. http://ijcai.org/Past Proceedings/IJCAI-77-VOL2/PDF/084.pdf. (The pages 964–969 were added to the proceedings as an addendum and are missing on the webpage.)

[54] AISB's Chairman Mike Brady acknowledged this success in a letter dated 04.04.1979 to Hans-Hellmut Nagel (contained in Nagel's files).

[55] In a letter from AISB's Chairman Mike Brady to Hans-Hellmut Nagel dated 31 January 1977 it is stated: "The vast majority of the membership of AISB, and of contributers and attendees at AISB-1 and AISB-2, were British".

[56] AISB-80 took place at the University of Amsterdam 1–4.7.1980; it was attended by nearly 150 participants and featured 35 presented papers.

[57] The claim of being European was explicitly expressed by AISB's newsletter: when Pat Hayes took over as editor in July 1969 he named it "The European AISB Newsletter" and under the editorship of Alan Bundy et al. it was named "European Newsletter", although in small print it was described as "The Newsletter of the British Computer Society Study Group on Artificial Intelligence and the Simulation of Behaviour" (note the "British"). In the Editorial of the October 1979 issue 35 of the AISB Quarterly Marc Eisenstadt expressed the view that "AISB seems at last to be fulfilling a genuine European-wide role. The present author, working in AI since 1969 at the TU München, had not seen any issue of the newsletter until around 1977.

[58] The text of the letter (enclosed in a cover letter) reads as follows:

EAAI – a European Association for AI?

IJCAI is an international conference. Assume it would (as it should) reflect the relative amount of research in AI in the different parts of the world then it could be concluded from the statistics of IJCAI-79 that in *whole of Europe* there is little more AI research than at Stanford (University and Research Institute) alone.

This letter addresses those in Europe who feel that AI research is much stronger than indicated by such a comparison and could even be strengthened considerably, who agree that the lack of a closer cooperation among the European AI-researchers and of a visible representation of AI in Europe are important reasons for such a disproportion. An important step towards more cooperation seems to be some form of organization.

It is sometimes argued that there is already a European organization which could take care of that: AISB. Of course, AISB is the strongest AI-organization in Europe and has done much for AI research. However, most people, in particular those from the continent, regard it as a *British* society rather than a European one, and there are numerous facts which support such a view.

Adopting this view we thus have a British AI-organization, a German one (the GI-Fachgruppe für "Künstliche Intelligenz" with some 250 addressees), a French one (integrated within the AFCET group for "Reconnaissance des Formes"), an analogue group in Italy, and looser ties in other European countries. Mainly because of the different native languages in these countries there is an essential need for such local organizations. Given this kind of structure the only natural European-wide organizational form therefore seems to be an umbrella association which links together all these local activities.

In accordance with this structural idea nothing else would be required than a board of representatives from local AI activities, not much more than ten people, say. According to the present status of AI activity it seems to be reasonable that one would envisage two representatives from Britain and one from each of the following communities: French, German, Italian, Benelux, Scandinavian, Eastern Europe.

The responsibility of these people would be to further any kind of cooperation of AI-research in Europe. In particular it should organize a European AI conference every two years, sponsor Summer-(or Winter-) Schools and Seminars on AI, implement a mechanism for dissemination of information of relevance among all European AI-researchers, and raise money for these and other activities.

[59] The extensive correspondence which followed Bibel's letter includes three remarkable and engaged letters exchanged between Pat Hayes (pro AISB, 15.11.1979 and 2.1.1980) and Wolfgang Bibel (pro EAAI, 8.12.1979), each with copies to AISB officers.

[60] The minutes of this meeting by Derek Sleeman appeared in the AISB Quarterly issue 38 of September 1980, p. 47.

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recognition of AISB's leading role prior to 1982 the conference was later counted as the fifth in the ECAI series in the understanding that the AISB conferences in 1974–1980 in retrospect are considered the first four ones.

At this memorable conference (with 282 registered attendees from 20 countries) the statutes worked out in the meantime were then approved in brown-pack meetings held on the grass of Orsay. Wolfgang Bibel was elected as the first ECCAI Chair, Yves Kodratoff Vice-Chair and Stefano Cerri Secretary [7]. Also it was decided to hold the next ECAI in 1984 in Pisa with Stefano Cerri as General Chair and Tim O'Shea as Program Chair, which already featured about 800 participants and 251 submitted papers [21].

ECCAI triggered the foundation of further national AI societies[61] including several ones in the eastern bloc. Today (2012) ECCAI represents 29 societies [32]. From that time on ECCAI has been running the biennial ECAI series of conferences. Further it acted as a lobby for AI at the Commission of the EU, for which purpose a special subcommittee consisting of Luigia Aiello, Jean-Pierre Jouannaud, Peter Raulefs (chair) and Yorik Wilks was established. Bibel and Raulefs became members of the Scientific Council at the Commission. In 1984 ECCAI started a Newsletter edited by Johannes Retti, sponsored and distributed by North Holland. In 1987 the *AI Communications* (AIComm) was founded as a journal with a close relationship to ECCAI and substituting the Newsletter.[62] So this year, 2012, we actually celebrate the 30th anniversary of the first ECAI proper, the 20th ECAI, and the 25th anniversary of AIComm.

In hindsight the foundation of ECCAI must be embedded into the global trends driven by the technological advances of those exciting years. The world was shrinking at a dramatic pace by the exponentially expanding air traffic as well as by ever improving means of communication. Quickly exploiting these new possibilities Japan had entered the globe as a new economic force, shaking the economic structures in the transatlantic alliance. The powerful player in this process was the Ministry of International Trade and Industry (MITI) which had guided the earlier successes in several Japanese industries such as the consumer electronics and automotive industry. Thereby Japan and MITI had earned a reputation for invincibility. Therefore the western world was sort of shocked and frightened when around 1980 Japan announced its Fifth Generation Computer Systems project (FGCS) in IT.

MITI had thoroughly prepared this project since the mid-seventies when in Japan like in Europe young AI researchers had become aware of the potential of AI technologies. But in contrast to Europe also an institutional player such as MITI took note of this potential. It decided to attempt to break out of the pattern which so far had characterized the Japanese industry, namely "follow the leader and do better". With this institutional backing the Japanese AI representatives at IJCAI-77 offered an attractive bid for hosting IJCAI-79 in Tokyo. During this conference we could then learn of the vision and plans of our Japanese colleagues such as Kazuhiro Fuchi (1936–2006)[63] from the Electrotechnical Laboratory (ETL) operated by MITI. Fuchi's vision was very much of the kind which in Section 3 I described as the Zusean alternative. The conference attendees spread the news in the western world.

A year later, in 1980, Fuchi along with Professor Tohru Moto-Oka (1929–1985) of the University of Tokyo, who in 1979 had become the Chairman of the Research and Planning Committee of FGCS, toured Europe and the US and personally invited six researchers[64] to give invited talks at the first FGCS conference in October 1981 with which the FGCS project was introduced. The grand Zusean vision was embedded into concrete plans to develop high performance parallel inference machines for logic-based knowledge processing.[65] The highly publicized conference attracted numerous national delegations and representatives from western governments including a

[61] For instance the Swiss AI researchers held a "preliminary meeting" 29th June 1984 at the Ecole de Traduction et d'Interpretation in Geneva and invited ECCAI's Chair for a talk on "AI in Europe".

[62] See [25]. For supporting both, the newsletter and the journal, the invaluable support of Einar Fredriksson from North Holland and later IOS Press is gratefully acknowledged.

[63] Like the European researchers mentioned in Section 4 Fuchi studied a year in the US, namely 1961–1962 at the University of Illinois (http://museum.ipsj.or.jp/en/pioneer/fuchi.html). There he already collaborated with Tohru Moto-Oka who himself worked at the Digital Computer Research Center of this university as a visiting associate professor in 1961–1963 (http://museum.ipsj.or.jp/en/pioneer/motoo.html).

[64] Jonathan Allen, USA; Wolfgang Bibel, Germany; Edward A. Feigenbaum, USA; Gilles Kahn, France; Bruce H. McCormick, USA; Philip C. Treleaven, UK. Their talks are contained in [47].

[65] Those who (mis-) interpreted – and were afraid of – the FGCS project as nothing else than an economic enterprise (and threat) later with some relief (mis-) judged the project a failure. If one understands the spirit behind the project in its entirety, it must be deemed a great success.

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high representative[66] from the Commission of the European Communities (CEC). In response to the FGCS project governments across the world started funding similar schemes.[67] These activities were embedded in a more general trend towards developing science and technology policies [4]. It is in this context that the foundation of ECCAI must be seen, the dynamics of which provided a strong stimulation.

The Commission of the European Communities (CEC) launched its European Strategic Programme for Research in Information Technologies (ESPRIT) which started in 1983.[68] Brussels had finally acknowledged that Europe was lagging far behind the US and Japan in IT and the national governments in Europe followed suit. For the leading European AI scientists an extremely hectic time began. They were expected to participate in national as well as in European projects, to build up research groups in their home universities, to teach crash courses in AI for industry, to establish the national and European infrastructure for AI as a discipline, to compete in terms of research quality on an international level, to advise and consult with governmental administration, to help our eastern European colleagues to catch up in AI,[69] and so forth. The present author in the mid-eighties for several years on the average gave two presentations per month in conferences, workshops, university seminars, industry symposia, project meetings, etc. in addition to heading a research group of more than a dozen scientists, to raising the funding for the projects, teaching, carrying out the administrational tasks involved, fulfilling the numerous roles within the AI community, and so forth. Some of those scientists, in lack of an appropriate position, had to fulfill those duties without support from their home institutions.

Conceiving and establishing an AI education in continental Europe was among our main responsibilities. In lack of such an education at universities, Wolfgang Bibel and Jörg Siekmann in 1982 founded the Frühjahrsschule für Künstliche Intelligenz (spring school for AI) which from then on has been held annually, since 1997 named Interdisziplinäres Kolleg Günne [33]. In the same vein but on a European rather than national level, Wolfgang Bibel and Philippe Jorrand in 1985 founded the ECCAI-sponsored Advanced Course for Artificial Intelligence (ACAI) which since then was held biennially at various places in Europe [34].[70]

[66] Jean-Marie Cadiou, Director of ESPRIT under the first Director General, Michel Carpentier, of the Task force for Information and Telecommunications (TF-ITT) at the CEC.

[67] Examples are: The Alvey Programme in Great Britain (1984–1989, 622 Mill. ECUs); PAFE, France; Program "Informationstechnik", Germany (90 Mill. ECUs for 7 AI projects); US Dept. of Defence projects like STARS (Software Technology for Adaptable, Reliable Systems), Strategic Computing, Strategic Defence Initiative; the establishment of the Microelectronics and Computer Technology Corporation (MCC) in the US, with funds of 25–35 Mill. US$ and a pooled staff of about 300 all working together in Austin, Texas; the EUREKA-PROMETHEUS-project (PROgraMme for a European Traffic of Highest Efficiency and Unprecedented Safety, 1987–1995, appr. 3 Billion ECUs); and so forth. See Chapter 7 in [53]. The German efforts are covered in [49].

[68] A key role in initiating ESPRIT was played by Viscount Etienne Davignon. In 1977 he became the Belgian Industry Commissioner (DG III) and later CEC's vice-president. In 1978 he commissioned FAST (European Forecasting and Assessment in Science and Technology), a small but influential unit set up within DG Research to study for the very first time future science issues on a European scale (Mike Rogers, personal communication – for some details see e.g. http://aei.pitt.edu/31042/1/P_29_80.pdf).
In 1979 Davignon created a Task force for Information and Telecommunications (TF-ITT). Its mission was "to study the long-term needs of the telematics sector (telecommunications and information technologies) and to draft a strategy for the EC as a whole to revitalize high-technology electronics industries" (U.S. Congress, Office of Technology Assessment, Competing Economies: America, Europe, and the Pacific Rim, OTA-ITE-498. Washington, DC: U.S. Government Printing Office, October 1991, p. 209). In the early eighties, not least in response to the Japanese FGCS efforts, the "Big Twelve" European IT companies (Bull, Siemens, etc.) approached Davignon realizing that they fell behind in international competitiveness in areas like IT, Office Systems and Manufacturing. He established the ESPRIT-Round Table. A small pilot programme (ESPRIT-0) was launched in 1983 funded with 11.5 MECUs. ESPRIT proper was started in 1984. It required the companies to collaborate together and along with scientists in the form of consortia in a precompetitive fashion. For the years 1984–1988 the CEC assigned 750 Mill. ECUs for ESPRIT matched with the same amount by industry, compared with 500 Mill. US$ assigned by Japan for FGCS. For more details see [53]. The author participated (among other ESPRIT projects) in the LOKI project (project number 107) which was among the very first funded pilot projects in ESPRIT.

[69] Some of the events in Eastern Europe of this kind – and attended by the author – were:
Symposium on Mathematical Foundation of Computer Science, Rydzyna, Poland, 1980;
International Conference on Artificial Intelligence and Information-Control Systems of Robots, Slomenice, CSSR, 1980, 1982, 1984 (the series until 1997 comprised 7 conferences);
I IFAC Symposium on Artificial Intelligence, Leningrad, USSR, 1983;
Artificial Intelligence – Methodology, Systems, Applications (AIMSA'84) Varna, Bulgaria, 1984;
Mathematical Methods for the Specification and Synthesis of Software Systems (MMSSSS'85), Scharmützelsee, DDR, 1985.

[70] For instance, the first ACAI 1985 was held 2–12 July at the Château de Chapeau-Cornu, Vignieu in France with 55 participants. A four-pages report by John Gallagher is contained in the *ECCAI Newsletter* **2**(3), (1985). The course material was published as [19].

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In the eighties many continental European universities noticed that AI attracts substantial funding which made this field respectable, hence they started installing AI professorships and appointing AI pioneers. Existing research institutions across Europe were extended with AI sections and new AI institutions were founded.[71] The most successful of them is the Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI) founded in 1988. Today it employs close to 800 people, features an annual budget of about 40 Mill.€ and has a permanent partnership with about a dozen of the leading companies in Germany.

Given the dramatic increase of interest in AI in Europe it was natural to hold IJCAI-83 in a continental western European city for the first time, namely in Karlsruhe, organized by Peter Raulefs and Jörg Siekmann.[72] The European complaints about the bias of this conference series mentioned above were finally taken into serious consideration so that in the eighties the IJCAIs became a truly international conference series.[73] All this is evidence for the fact that AI around 1985 after a decade of successful efforts was in fact fully established in Europe.[74]

6. The prospects of AI

The AI boom in the eighties as described in the previous section was economically motivated. It had little or nothing to do with the Zusean alternative which we described in Section 3. The same is true for the so-called AI winter which followed suit as a reaction to the disappointment after highly exaggerated economic expectations. AI, narrowed down to a set of special methods and technologies, has remained well established and as such enormously successful though. But since its inception it split and has become integrated within technology-oriented IT and CS (or Informatics) on the one side and CogSci, Psychology, and Neuroscience on the other to an extent that AI as a discipline with a grand vision has come out of sight and is hardly any more recognizable. So today we are facing the difficult and urgent question: who instead might drive the realization of the Zusean alternative in the future. In order to illustrate the urgency let us expand on the issues involved in this alternative.

Humans have evolved for a living in small tribes and in local environments only. But with today's technology everybody may – and does – contribute to global effects without the mental endowments necessary for taking into account all constraints and consequences involved under a global view. In consequence of this undeniable fact humankind is faced with a fundamental problem as already indicated in Section 3. Namely, on the one hand humans from a global point of view suffer from numerous innate mental weaknesses (which in the environments of the Stone Age proved to be strengths). In Section 3 we mentioned some of these weaknesses along with pertinent references to the literature. In a global world, on the other hand, these deficiencies are no more tolerable and in fact dangerously destructive to a degree as to threatening our world's prosperity.

This is of course no new insight and many attempts have been made to somehow overcome these human deficiencies. Among these are religions, legal systems, the methodology of the sciences, the establishment of democratic parliaments, and of the UN, and even the declaration of infallibility for some rulers (e.g. religious ones). None of these and others overcomes the core of the problem because they all necessarily and crucially involve people with their known weaknesses. Science represents a notable step into the right direction, but does not cover (and offer any remedy for) the truly human affairs (like politics).

ACAI 1987 held 28 July–7 August at Soria Moria, Norway, was attended by 188 participants. Apart from the AI courses it also featured a play entitled "The Sleeping Beauty or AI comes of age" written and directed by the participants Manny Rayner and Caroline Knight and performed by 23 of the participants. The course material was published as [45].

[71] This is not the place to list these institutions exhaustively; examples are: Institut national de recherche en informatique et en automatique (INRIA), founded 1967; Gesellschaft für Mathematik und Datenverarbeitung (GMD) founded 1968, now integrated into the Fraunhofer Gesellschaft zur Förderung der angewandten Forschung eV (FhG); European Computer-Industry Research Center (ECRC), founded 1984 by Siemens, ICL and Bull and located in Munich; Fondazione Bruno Kessler (FBK) with its Center for Information Technology (FBK-IRST), Trento; Laboratoire d'Analyse et d'Architecture des Systèmes (LAAS-CNRS); Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier (LIRMM); Artificial Intelligence Research Institute of the Spanish National Research Council (IIIA-CSIC).

[72] The initiative for bringing IJCAI to Karlsruhe was started in a letter of 3 May 1977, i.e. six years before the event, by Wolfgang Bibel to IJCAI's General Chair Woody Bledsoe.

[73] At IJCAI-81 another panel "AI Methodology: Transatlantic Views" was held to address the problem. The board of trustees from then on took decisive steps to internationalize the series.

[74] An account of the European situation in the mid-eighties is contained in [8].
Remaining weaknesses concerning the European situation were described in [9].

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What mankind would need is a super-human intelligence which on the basis of all available knowledge always would follow the rules of consistent, logical and rational thinking taking a global and far-sighted perspective. It might be realized – or at least approximated – in the form of artificially intelligent and rational agents (AIRA). These could assist anyone in the daily behavior and in all decisions, and this way compensate for the human intellectual and ethical deficiencies. Like navigation systems guide us for optimizing our travel routes, social navigation systems – or advanced recommender systems – might guide us in our daily lives for the better of ourselves, our environment and for the entire globe. This still amounts to a grand goal (or rather vision) which will not be reached in the near future. Rather it can only be approached in a stepwise fashion.[75] It features many aspects, some of which are now briefly discussed.

AIRA is *not* supposed to model the exact kind of intelligence as experienced in humans because human intelligence has proved to be insufficient for a peaceful, just and sustainable development of the world. Just recall names like Hitler, Stalin, Saddam Hussein – you continue the list naming your "favorites". So we are faced with the enormous challenge to define AIRA's intelligence and rationality with our biased human intelligence in the first place. That is, we first would have to agree on general normative principles, like global sustainability, human equality on a global scale, human rights as well as rights for all other creatures, justice, logical correctness, ethical norms, fraud avoidance, and so forth. These principles, unlike the legal system in its current form, would have to be defined in a precise, consistent and formal way (on the basis of methods which include those from AI) resulting in what might be regarded the world's fundamental constitution.[76] An AIRA would then be required always to comply fully and consistently with this constitution.[77]

Knowledge and its processing lies at the heart of the AIRA vision (recall the "conquest of the meta-knowledge level" of Section 3).[78] One needs to classify knowledge in precise ways so that its origin is transparent and thus the reliability of a certain piece of knowledge becomes sort of measurable.[79] Uncertain or even religious beliefs are to be marked and treated accordingly. As we know from our daily lives, decisions improve with additional pertinent and reliable knowledge. So AIRA would have to take into account all pertinent knowledge globally available for any advice concerning even supposedly minor decisions in our personal lives such as planning for the next holidays or for the purchase of a new car or suite. All the more AIRA would be needed for political or entrepreneurial decisions. In attempting to build AIRA one should perhaps start with restricted areas such as the legal domain.[80] As AIRA matures in such a restricted area, it could be extended to cover others such as ethics, politics, and so forth.[81]

Of course, after more than half a century of AI research we are more than well aware of the enormous challenge as well as of the risks involved in such a venture. But I hope to have made clear that heading towards this direction seems to be the only way to lead the globe into a sustainable future. Without trying to strive for this goal we might fail for sure. Humankind simply has to decide on which grand goals it would like to put its priorities and focus on this challenge rather than on similarly costly, but less urgent ones. Also, one will have to expect fierce opposition from ordinary people and leaders alike against handing over some of their responsibility and autonomy to the advice of an artificial agent. We have to try out, demonstrate the advantages for all, and with this backing convince others. After all people have no problem with asking medicine for help if they suffer from health problems. Why should we be so averse to help in case of intelligence problems? People also tolerate the constraints imposed by legal systems, although these still are rather inconsistent and shaky.[82]

From our sketch of the task to build AIRA it is clear that the responsibility for its development cannot be left with researchers in today's restricted AI but requires the combined skills from many different disciplines. So as to our question concerning a leader, posed at the beginning of this final section, one might first think of an interdisciplinary effort in realizing the

[75] The approach described in [65] may be regarded as a preliminary approximation to AIRA.

[76] Details about such a normative approach can be found in [12].

[77] Even when AIRA might evolve by self-improvement we could and should make sure that the result is to our liking, as is argued in [46].
"Humanity as a whole must contribute to a shared vision for our future" the author says in this context on p. 37.

[78] The role of knowledge among other aspects has been described in [16].

[79] For a comprehensive treatise on knowledge, or rather on strongly held beliefs, see [44].

[80] See [12].

[81] The author has outlined his views on how to cope with the human condition from an AI perspective in [11].

[82] See [12].

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AIRA vision. However, history teaches that grand visions cannot successfully be pursued unless there is some kind of uniform organization behind it. But as described above, there is no true leader in sight unless we revive AI as a unified discipline by itself, possibly merging current AI with CogSci, Cognitive Psychology, Cognitive Neuroscience[83] etc. under some new name (like the one proposed by the present author, viz. Intellectics [6][84]).[85]

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References

[1] S.S. Adams et al., Mapping the landscape of human-level artificial general intelligence, *AI Magazine* **33**(1) (2012), 25–41.
[2] E. Alonso, The AISB: 1964 and all that (up to 1980). Talk given at the University of Edinburgh, September 2012.
[3] J.R. Anderson, *Cognitive Psychology and Its Implications*, Freeman, San Francisco, 1995.
[4] I. Asher, A. Keynan and M. Zadok (eds), *Strategies for the National Support of Basic Research: An International Comparison*, The Israel Academy of Science and Humanities, 1995.

[83] Like other neuroscientists Sebastian Seung sees the need for a close cooperation when he writes:
"With the aid of machine intelligence, we will finally see the connnectomes that have eluded us for so long" [56].

[84] See also [18].
The arguments for the necessity of a joint venture of AI and CogSci have been emphasized again in [14,17]. There are initiatives similar to what I propose here under the label of Artificial General Intelligence (AGI); see e.g. [1]. At present I cannot see that any of these initiatives carry the potential of becoming a leading discipline.

[85] The Human Brain Project under the leadership of Henry Markram, funded as a flagship project by the EU, could be of interest also for AIRA. The project's goal is a simulation of the workings of the entire human brain.

[5] F. Baader and W. Thomas (eds), Alan Turing, Themenheft, *Informatik Spektrum* **35**(4) (2012).
[6] W. Bibel, "Intellektik" statt "KI" – Ein ernstgemeinter Vorschlag (Intellectics instead of AI – A serious proposal), *Rundbrief der Fachgruppe Künstliche Intelligenz in der Gesellschaft für Informatik* **22** (1980), 15–16.
[7] W. Bibel, ECCAI got started, *Rundbrief der Fachgruppe Künstliche Intelligenz in der Gesellschaft für Informatik* **28** (1982), 46–47.
[8] W. Bibel, Artificial Intelligence in Europe, in: *Proceedings of AIMSA'84, Artificial Intelligence – Methodology, Systems, Applications*, W. Bibel and B. Petkoff, eds, North-Holland, Amsterdam, 1985, pp. 3–10.
[9] W. Bibel, ECCAI and the European malaise, *AI Communications* (1987), 5–7.
[10] W. Bibel, Intellectics, in: *Encyclopedia of Artificial Intelligence*, 2nd edn, S.C. Shapiro, ed., Wiley, New York, 1992, pp. 705–706.
[11] W. Bibel, *Lehren vom Leben – Essays über Mensch und Gesellschaft*, Deutscher Universitäts-Verlag, Wiesbaden, 2003.
[12] W. Bibel, AI and the conquest of complexity in law, *Artificial Intelligence and Law Journal* **12** (2004), 159–180.
[13] W. Bibel, The beginnings of AI in Germany, *KI Heft* **4** (2006), 48–54.
[14] W. Bibel, Research perspectives for logic and deduction, in: *Reasoning, Action, and Interaction in AI Theories and Systems – Essays in Honor of Luigia Aiello on the Occasion of Her 60th Birthday*, O. Stock and M. Schaerf, eds, LNAI, Vol. 4155, Springer, Berlin, 2006.
[15] W. Bibel, Early history and perspectives of automated deduction, in: *Proceedings of the 30th Annual German Conference on Artificial Intelligence (KI-2007)*, J. Hertzberg, M. Beetz and R. Englert, eds, LNAI, Vol. 4667, Springer, Berlin, 2007, pp. 2–18.
[16] W. Bibel, General aspects of intelligent autonomous systems, in: *Intelligent Autonomous Systems: Foundations and Applications*, D.K. Pratihar and L.C. Jain, eds, SCI, Vol. 275, Springer, Berlin, 2010, pp. 5–27.
[17] W. Bibel, KI ohne Geist (AI without mind), *KI* **25** (2011), 299–302.
[18] W. Bibel, Intellectics, in: *Encyclopedia of Artificial Intelligence*, 2nd edn, S.C. Shapiro, ed., Wiley, New York, 1992, pp. 705–706.
[19] W. Bibel and Ph. Jorrand, eds, Fundamentals of Artificial Intelligence, in: *Advanced Course for Artificial Intelligence, Vignieux, Juli 1985*, LNCS, Vol. 232, Springer, Berlin, 1986 (2nd edn, 1988).
[20] H. Bruderer, K. Zuse and die Schweiz, *Wer hat den Computer erfunden?*, Oldenbourg Wissenschaftsverlag, München, 2012.
[21] S. Busemann, Eindrücke von der 6. ECAI, in: *84. Rundbrief künstliche Intelligenz*, Nr. 35/36, S.21f, 1984.
[22] E.R. Caianiello, ed., Automata theory, in: *6th International Spring School of Physics*, 1964, Ravello, Italy, Academic Press, New York, 1966.
[23] F.C. Delius, *Die Frau, für die ich den Computer erfand*, Rowohlt, Berlin, 2009.
[24] H. Frank, *Kybernetische Maschinen – Prinzip und Anwendung der automatischen Nachrichtenverarbeitung*, Fischer-Verlag, Frankfurt, 1964.
[25] E.H. Fredriksson, History of AI publications at IOS Press and North-Holland/Elsevier, in: *ECAI 2012*.

AUTHOR COPY

[26] R. Glaschnick and N. Ryska, Alan Turing und Deutschland: Berührungspunkte, *Informatik Spektrum* **35**(4) (2012), 295–300.
[27] G. Günther, *Das Bewußtsein der Maschinen*, Agis, Baden-Baden, 1957.
[28] http://en.wikipedia.org/wiki/Lists_of_extinct_animals.
[29] http://en.wikipedia.org/wiki/Norbert_Wiener.
[30] http://en.wikipedia.org/wiki/Karl_Steinbuch.
[31] http://xputers.informatik.uni-kl.de/papers/publications/karl-steinbuch_en.html.
[32] http://www.eccai.org/member/index.shtml.
[33] http://de.wikipedia.org/wiki/Interdisziplinäres_Kolleg_Günne.
[34] http://www.eccai.org/acai.shtml.
[35] D. Kahneman, *Thinking, Fast and Slow*, Farrar, Straus and Giroux, New York, 2011, p. 411.
[36] R. Kowalski, Predicate logic as a programming language, *Proc. IFIP-74*, North-Holland, Amsterdam, 1974, pp. 569–574.
[37] J. Lighthill, Artificial intelligence: A general survey, in: *Artificial Intelligence: A Paper Symposium*, Science Research Council, 1973.
[38] W.N. Locke and A.D. Booth (eds), *Machine Translation of Languages: Fourteen Essays*, Technology Press, Cambridge, 1955.
[39] I.M. Makarov (ed.), *Cybernetics Today – Achievements, Challenges, Prospects*, Mir Publishers, Moscow, 1984.
[40] J. McCarthy, Computers with common sense, in: *Proceedings of the Symposium on Mechanisation of Thought Processes*, Vol. 1, H.M. Stationary Office, Teddington, 1959, pp. 77–91.
[41] W. McCulloch and W. Pitts, A logical calculus of the ideas immanent in nervous activity, *Bulletin of Mathematical Biophysics* **7** (1943), 115–133.
[42] G.E. Moore, Cramming more components onto integrated circuits, *Electronics* **38**(8) (1965), 114–117.
[43] N.J. Nilsson, *The Quest for Artificial Intelligence: A History of Ideas and Achievements*, Cambridge Univ. Press, Cambridge, 2009.
[44] N.J. Nilsson, *Beliefs – What They Do for Us, How We Get Them, How to Evaluate Them*, Stanford University, 2012, available at: http://ai.stanford.edu/∼nilsson.
[45] R. Nossum, ed., *Advanced Topics in Artificial Intelligence*, LNCS, Vol. 345, Springer, Berlin, 1989.
[46] S.M. Omohundro, *The Nature of Self-Improving Artificial Intelligence*, 2008, available at: http://omohundro.files.wordpress.com/2009/12/nature_of_self_improving_ai.pdf.
[47] *Proceedings of International Conference on Fifth Generation Computer Systems*, T. Moto-Oka, ed., North-Holland, Amsterdam, 1982.
[48] *Proceedings of the 1968 Symposium*, Lecture Notes in Mathematics, Vol. 125, M. Laudet et al., eds, Springer, Berlin, 1970.
[49] B. Reuse and R. Vollmar, Hrsg., *Informatikforschung in Deutschland*, Springer, Berlin, 2008.
[50] J.A. Robinson, The role of logic in computer science and artificial intelligence, in: *Fifth Generation Computer Systems 1992*, Ohmsha and IOS Press, 1992, pp. 199–210.
[51] R. Rojas (ed.), *Die Rechenmaschinen von Konrad Zuse*, Springer, Berlin, 1998.
[52] F. Rosenblatt, The Perceptron – a perceiving and recognizing automaton, Report 85-460-1, Cornell Aeronautical Laboratory, 1957.
[53] W. Sandholtz, *High-Tech Europe – The Politics of International Cooperation*, University of California Press, Berkeley, CA, 1992.
[54] E. Schrödinger, *What is Life?*, Cambridge Univ. Press, Cambridge, 1944.
[55] O. Selz, *Über die Gesetze des geordneten Denkverlaufs*, Spemann, Stuttgart, 1913 (About the Laws of the Orderly Thinking Process, Transl. WB).
[56] S. Seung, *Connectome – How the Brain's Wiring Makes Us Who We Are*, HMH, Boston, 2012, p. xvi.
[57] C.E. Shannon, Programming a digital computer for playing chess, *Philosophy Magazine* **41** (1950), 356—375.
[58] H.A. Simon, *Models of My Life*, MIT Press, Cambridge, 1996, p. 190.
[59] A.G. Speedie Pask, *An Approach to Cybernetics*, Hutchinson, 1961.
[60] K. Steinbuch, Die Lernmatrix, *Biological Cybernetics* **1**(1) (1961), 36–45.
[61] K. Steinbuch, Können und sollen menschliche Funktionen bei der Raumfahrt von Automaten übernommen werden?, in: *Kybernetische Maschinen – Prinzip und Anwendung der automatischen Nachrichtenverarbeitung*, H. Frank, ed., Fischer-Verlag, Frankfurt, 1964, p. 294.
[62] K. Steinbuch, Learning Matrix, Patent CA000000717227A, Publication 31.08.1965.
[63] K. Steinbuch, *Informatik: automatische Informationsverarbeitung*, 1957.
[64] K. Steinbuch and B. Widrow, A critical comparison of two kinds of adaptive classification networks, *IEEE Transactions on Electronic Computers* (1965), 737–740.
[65] R.H. Thaler and C.R. Sunstein, *Nudge – Improving Decisions about Health, Wealth, and Happiness*, Yale Univ. Press, 2008.
[66] N.W. Timoféef-Ressovsky, K.G. Zimmer and M. Delbrück, *Über die Natur der Genmutation und der Genstruktur*, Nachrichten der Gesellschaft für Wissenschaften zu Göttingen, Fachgruppe VI, Neue Folge, Band 1, Nr. 13, 1935, S. 190–245.
[67] A. Turing, Computing machinery and intelligence, *Mind* **59** (1950), 433–460.
[68] A.M. Turing, On computable numbers, with an application to the Entscheidungsproblem, *Proc. London Math. Soc., Ser. 2* **42** (1936), 230–265.
[69] A.M. Turing, A correction, *Proc. London Math. Soc., Ser. 2* **43** (1937), 544–546.
[70] A.M. Uttley, Information, machines, and brains, *IEEE Transactions on Information Theory* **1** (1953), 143–149.
[71] K. Zuse, *Der Plankalkül*, Bericht GMD-63, Birlinghoven, 1972.
[72] K. Zuse, *Der Computer mein Lebenswerk*, Verlag Moderne Industrie, München, 1970, pp. 112–118. (Republished in: Springer, Berlin, 1984, 1993; Engl.: *The Computer – My Life*, Springer, Berlin, 1993.)
[73] K. Zuse, Über den allgemeinen Plankalkül als Mittel zur Formulierung schematisch-kombinativer Aufgaben, *Archiv der Mathematik* **1** (1948/1949), 441–449.

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